IIP-16

MASTR – Multi Application Smallsat Tri-band Radar

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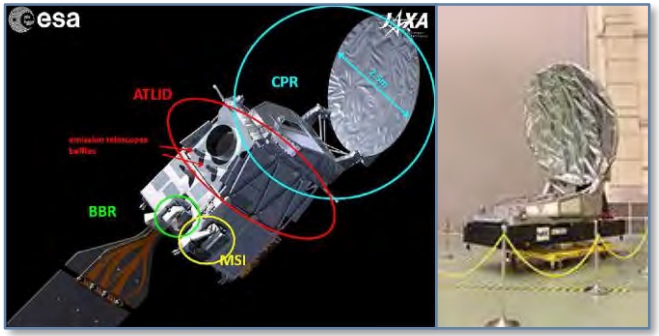
Motivation

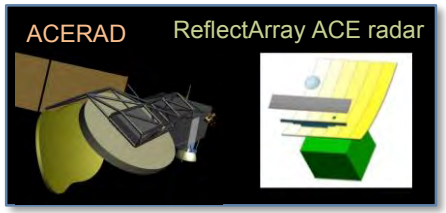
Clouds and Precipitation

- Addressed separately by active instruments so far (i.e., TRMM, GPM & RainCube at Ku and Ka band, vs CloudSat and EarthCARE at W-band).
- Three-frequency single aperture radar enables holistic view of the cloud-precipitation process
  - e.g., J. Leinonen, et al. 2014, ACE decadal survey mission concept (Ka-/ W-band), Cloud and Precipitation Processes Mission (CaPPM) concept. (Ku-, Ka-, W-band) responses to Decadal Survey 2017.
- Technology maturity over the last decade enables scanning at W-band as well as tri-band integration

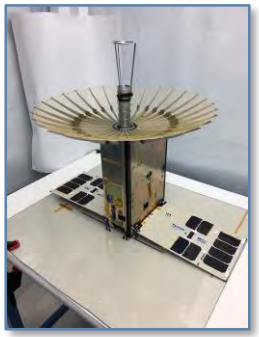
GPM – Dual-frequency Precipitation Radar – NICT/JAXA
Ku/Ka, Scanning, Precipitation



EarthCARE – Cloud Profiling Radar CPR – W-Band
NICT/JAXA



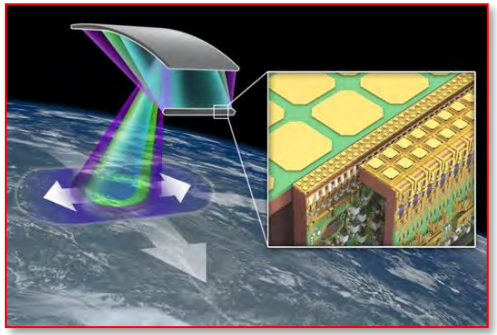
ES DS 2007:
ACE Mission Concept Radar
Ka/W, Doppler, Scanning (Ka)



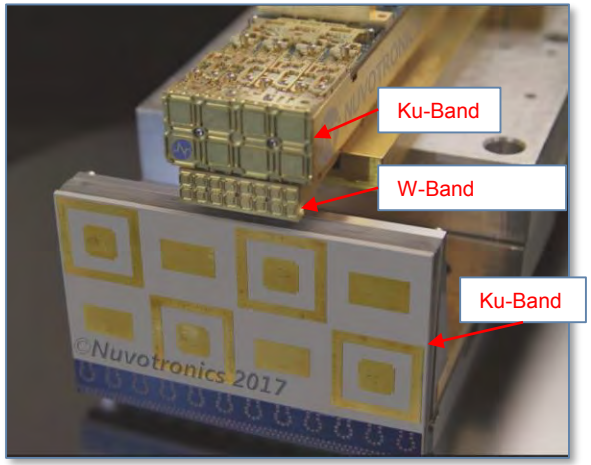
RAIN Cube – JPL/NASA Invest
Ka-band, 6U Cubesat

What is MASTR

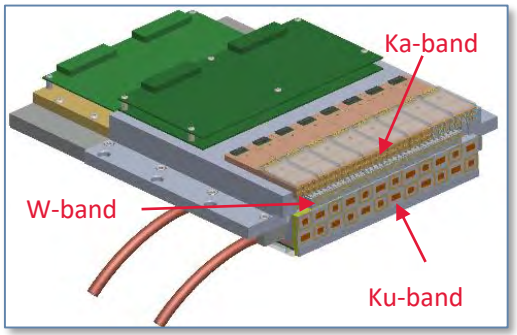
MASTR is tri-band (Ku-, Ka-, W-band) **scalable** phased array radar. Designed to work as a Cloud and Precipitation Radar, an Altimeter, or a Scatterometer (in a Spinning platform). A modular, scalable architecture enables technology maturation via an airborne demonstration AirMASTR. A compact profile allows multiple implementations depending of mission requirements, power, and budget available (ranging from SmallSats to large platforms).



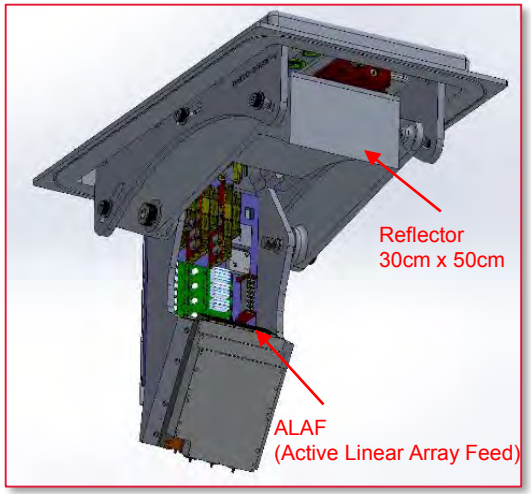
Space MASTR Concept
Courtesy of Nuvotronics Inc.



Scanning Array Tiles – SAT
SBIR DATA RIGHTS: Contract Number: NNX15CP18C.



AirMASTR – Active Linear Array Feed -ALAFs



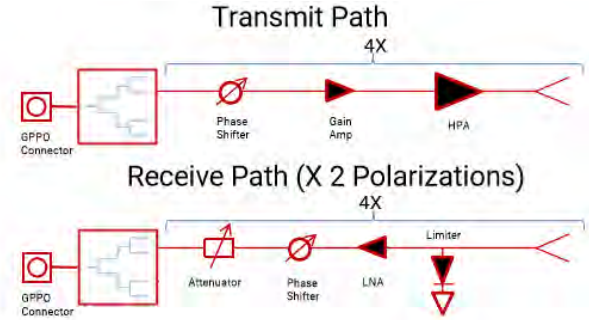
AirMASTR – Instrument Model

Ka and Ku Scanning Array Tiles

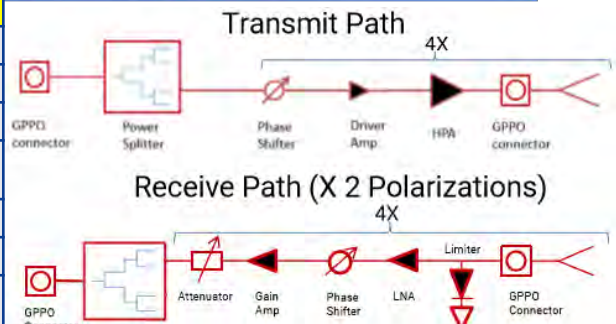
- **All modules assembled**
  - Easy Assembly: Precision alignment and wirebonding blocks
  - Ease of Test and Rework- Isolation frames, lids and re-connectable antenna

Ka-Band

Ku-Band

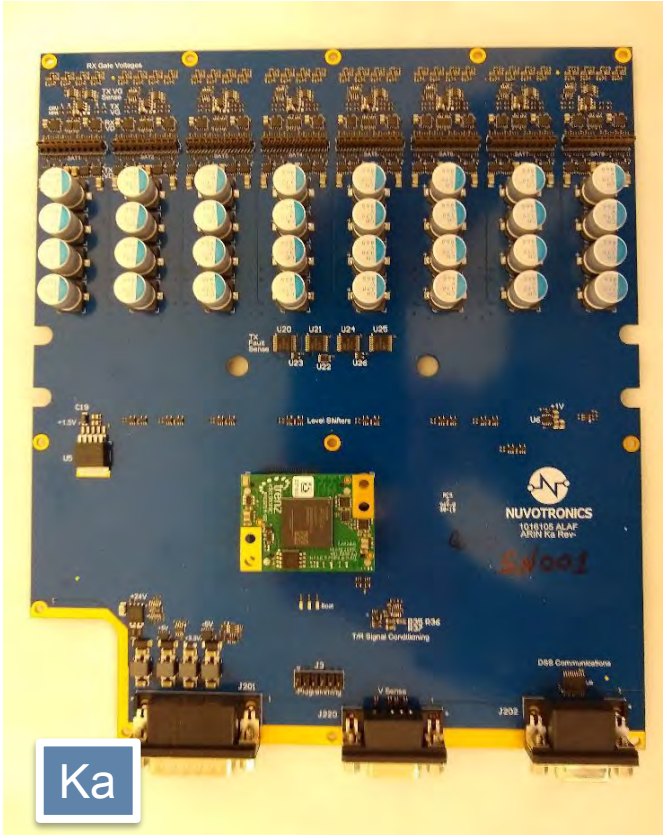


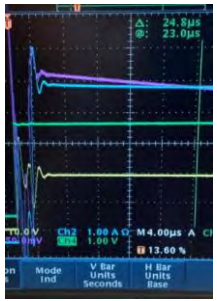
Description	Ku-Band	Ka-Band
Frequency	13.6GHz	35.75GHz
Tx elements	4	
Rx elements	4	
Tx power per element (peak)	+36.7dBm	+43dBm
Tx duty cycle	10%	
Rx noise figure	4dB	4.5dB
Size	64 x 44 x 175 mm	23.6 x 16 x 54 mm

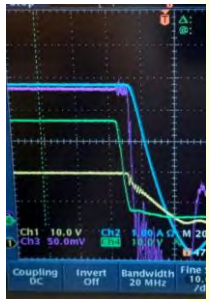


Ka and Ku ARRIN Board

- Up to 16 SPI buses in parallel for control and programming of Tx/Rx channels
- Charged storage capacitor banks for transmitter pulsed DC power
- Differential power delivery mitigates external noise pickup
- Voltage rail sensing reduces voltage drop effects for power delivery
- OVLO/UVLO and power sequencing protects ARIN and SAT circuits



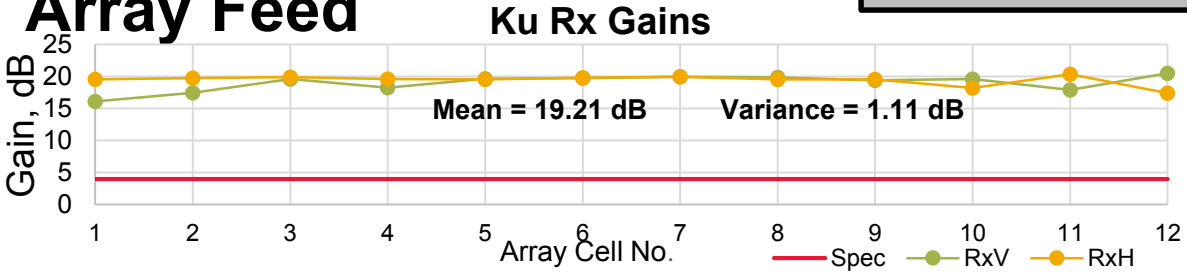


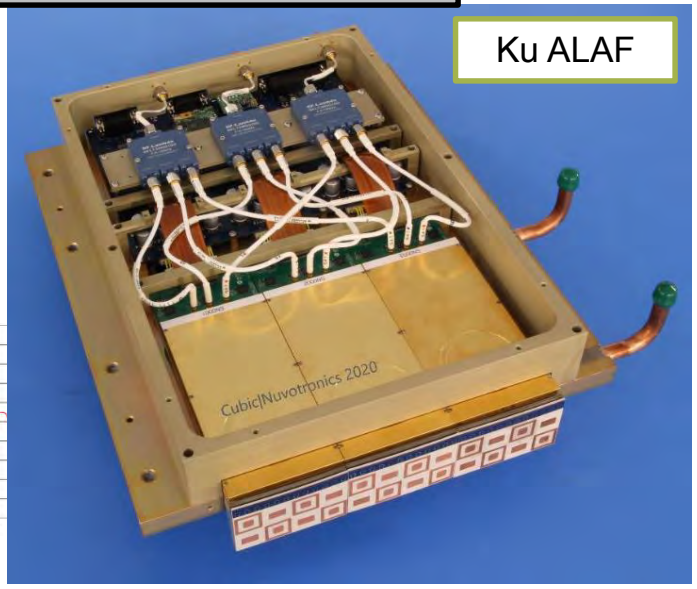


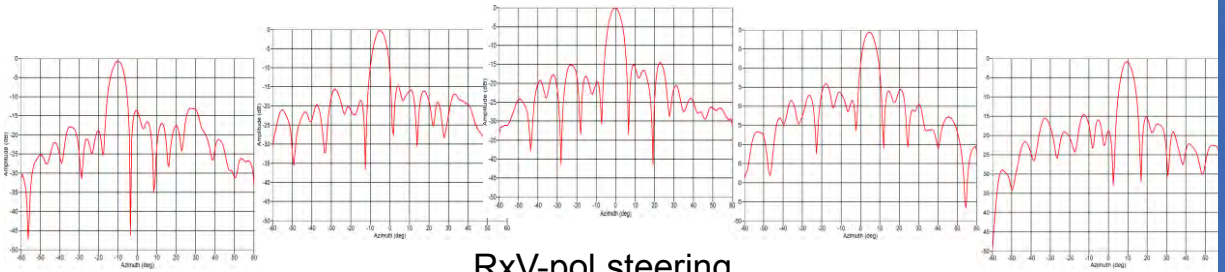
- Pulse into Ku HPA
  - Pulse shows 2uS leading edge delay with no trailing edge RF turn off prior to trigger off condition.
- Detected RF shows rapid turn off at trailing edge

Ku Active Linear Array Feed

PCB/SMT technology, 3-way COTS combiners, SMA cables result in reduced cost and low loss

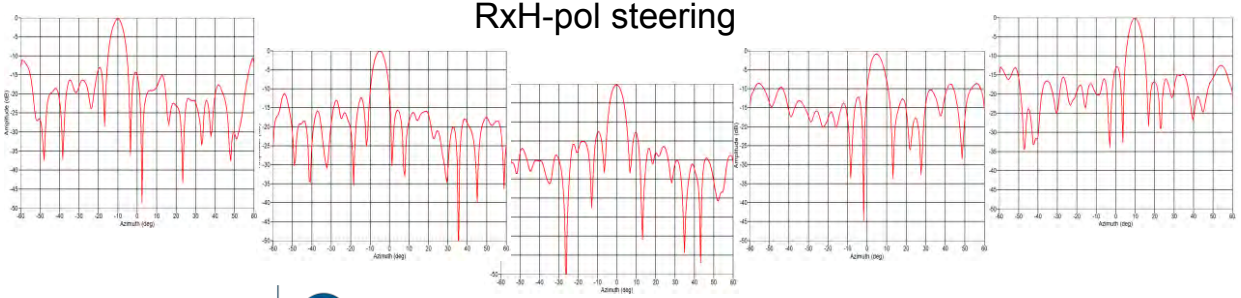


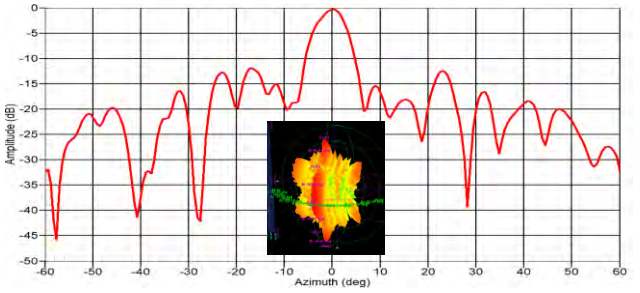




RxV-pol steering

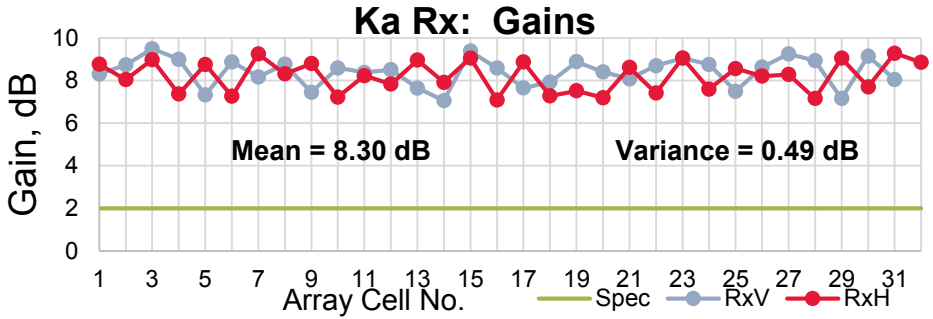
RxH-pol steering





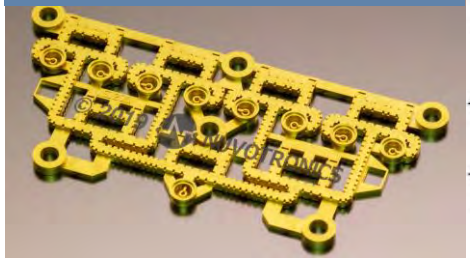
Tx at boresight

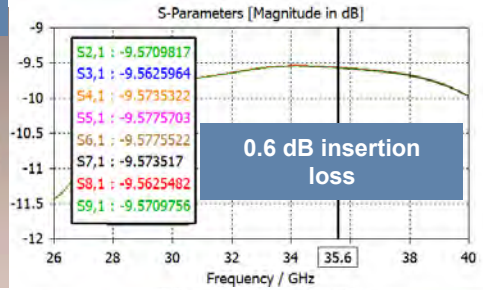
Ka Active Linear Array Feed

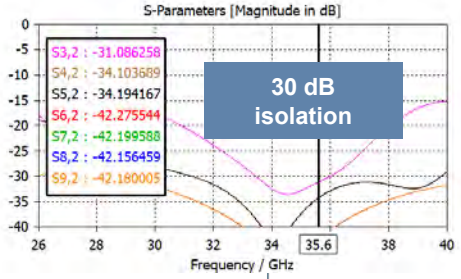


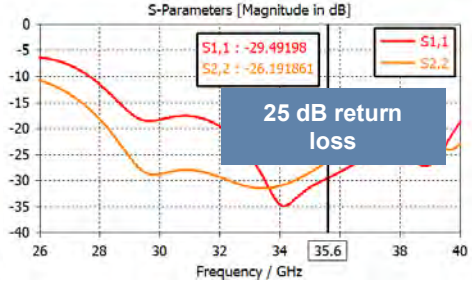
- **High uniformity and low loss using PolyStrata® technology with MMIC/wirebonds**
- **PolyStrata® 8-way combiners and 0.086 coax cables result in low RF signal loss**

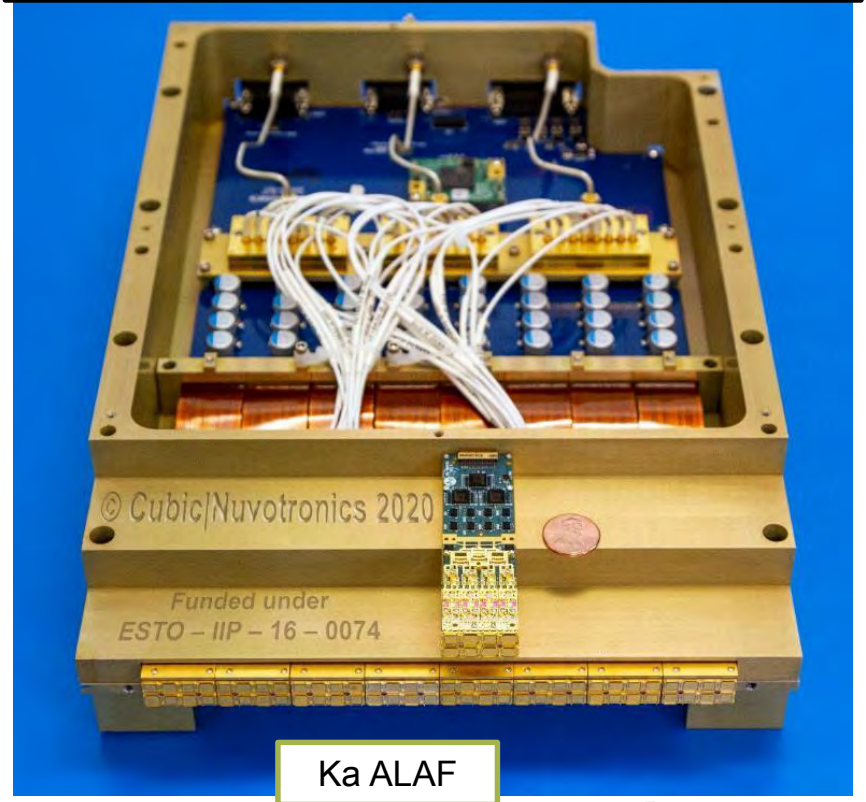
PolyStrata® combiner





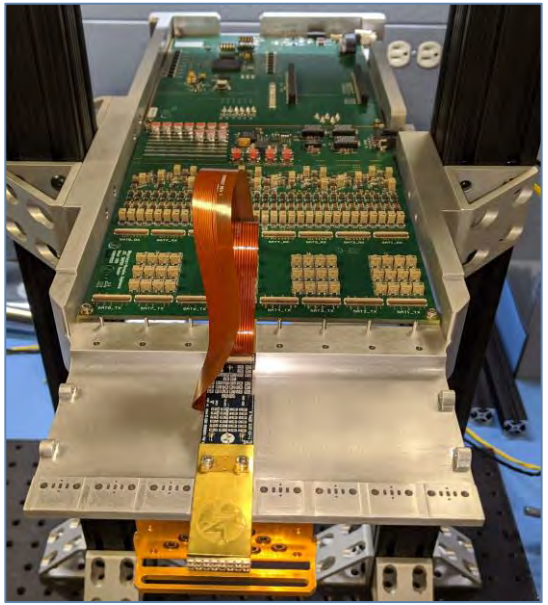






Status and Future Work

- Estimated first flight: June 2021.
- Ku-band Active Linear Array Feed has been characterized.
- Ka-band Active Linear Array Feed characterization in progress.
- W-band Active Linear Array Feed integration in progress.
- Instrument integration scheduled for Feb-2021.



W-Band Scanning Array Tile Test
W-Band ALAF (Active Linear Array Feed) Development

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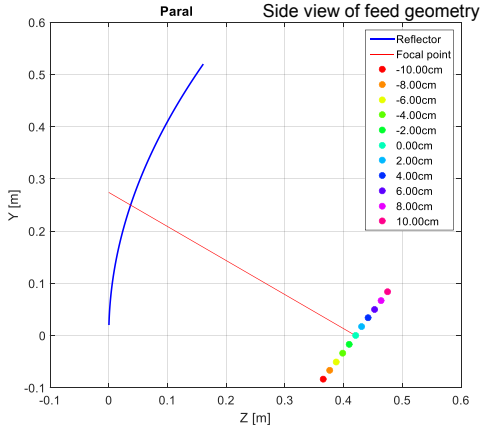
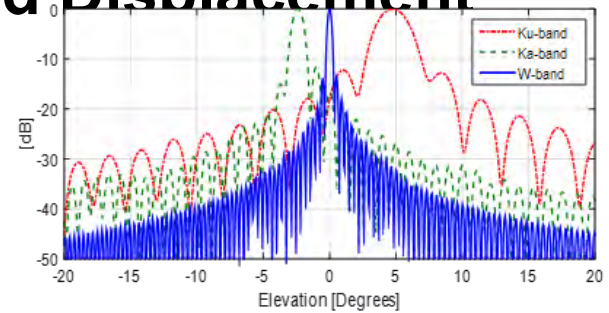
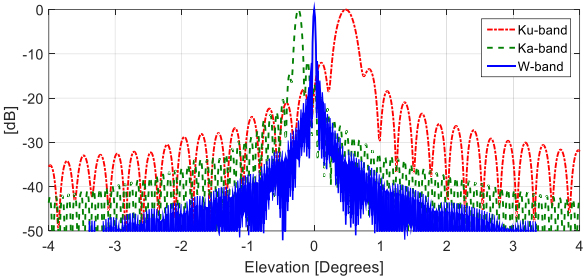
Antenna Reflector Scaling and Feed Displacement



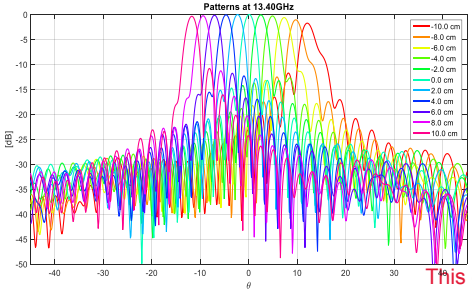


Along Track Radiation Pattern of Airborne Concept (50cm)

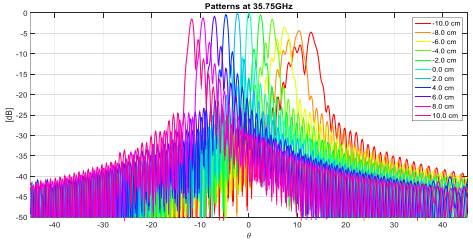


Along Track Radiation Pattern of Spaceborne Concept (5m)

Along track pattern at 13.4GHz vs feed location



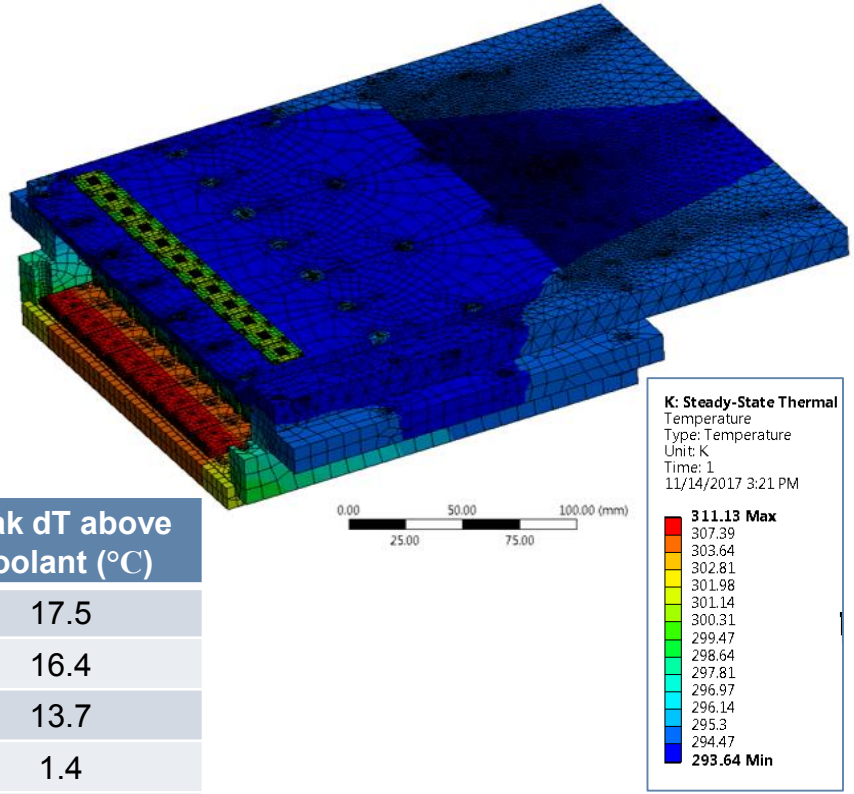
Along track pattern at 35.7GHz vs feed location



In both cases the W-band feed is at the focal point of the reflector, the Ka-band displace 2cm in one direction and the Ku-band displaced 4cm in the opposite direction.

Estimated ALAF Temperature Map

- Temperature rise estimates based on thermal load estimates determined by IC efficiency, location and operation modes.
- Isothermal boundary condition in coolant tube = 293.6K
- Peak temperature rise of all metal structures is 17.5°C



Component	Peak dT above Coolant (°C)
Ku SAT	17.5
W SAT	16.4
Ka SAT	13.7
Cold Plate	1.4
Waveguide Combiner	3.9

- MASTR-IIP16

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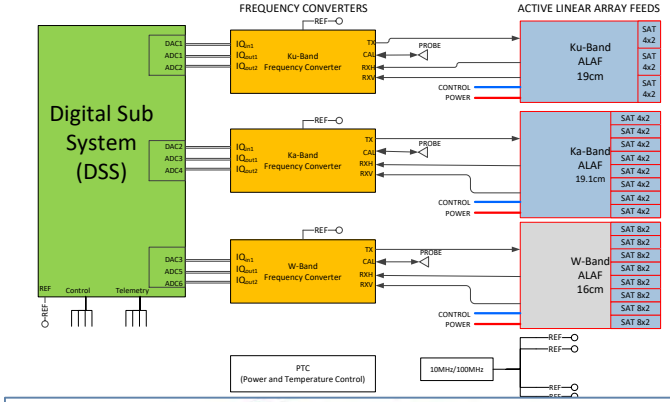

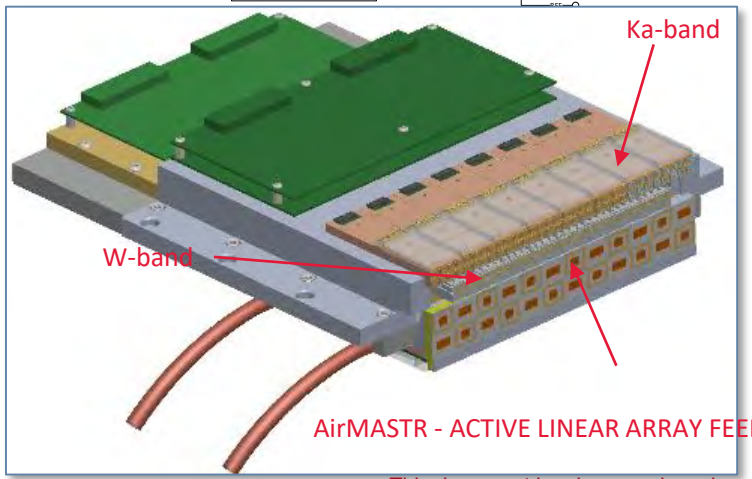

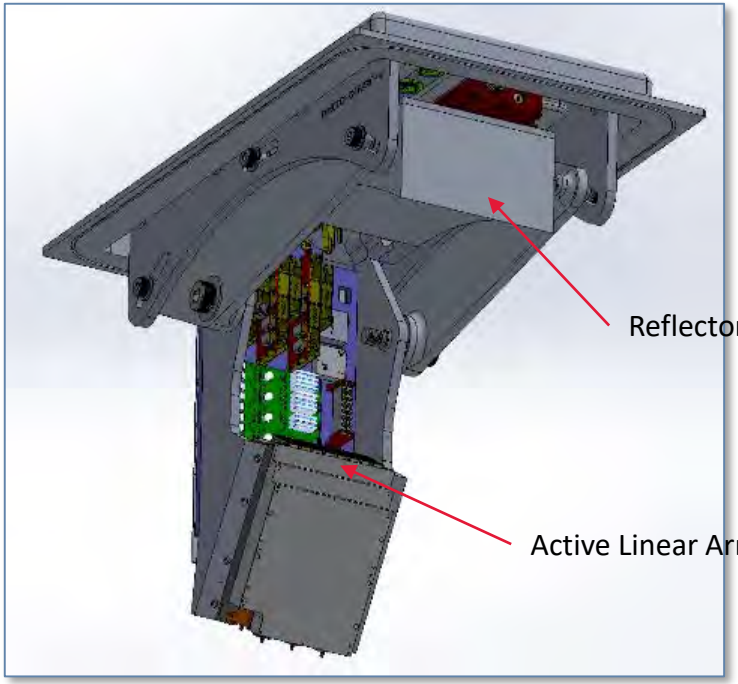

- Active Linear Array Feeds closely spaced at the focal point of a parabolic-rectangular reflector.
- Feed closely spaced, yet each band is independent of the others.
- Configuration shown has 3 Ku-band Scanning Array Tiles - SATs, 8 Ka-band SATs, and 8 W-band SATs.